Coherent Diffraction Imaging of Nanostructures with Hard X-Rays

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Modern high-brilliance synchrotron sources provide intense X-ray beams possessing a high degree of coherence which allows for realising lensless X-ray microscopy using the oversampling technique. Thereby the coherent diffraction pattern is sampled on a scale finer than $2\pi/D$, with D denoting the size of the object. A model-free reconstruction of the object is obtained by using iterative phase-retrieval algorithms that transform the image back and forth between direct and reciprocal space while applying appropriate constraints in each domain[1]. The spatial resolution of this approach is limited by the wavelength of the used radiation only, and the imaging process does not suffer from lens errors. Moreover, one can take advantage of the high penetration depth and element specificity of X-rays.
Model-free structure determination of isolated non-periodic objects on the nanoscale has been demonstrated in the past by using soft [2, 3] and hard X-rays [4, 5]. Experiments with hard X-rays in SAXS geometry are, however, difficult due to the missing forward data caused by the beamstop protecting the CCD camera. Thus, essential information on the overall dimensions of the sample may be lost and there are endeavours to overcome that problem by means of clever algorithms [6, 7]. One of those is the so-called "shrink wrap" (SW) algorithm [6], which iteratively constructs a new object support based on the actual image estimate [6, 3]. However, information on the limit up to which the SW algorithm reliably finds the true object support is missing in the literature.
Here, we report on coherent diffraction imaging experiments of model nanostructures using hard X-rays at beamline ID10C at the ESRF. Beside concrete reconstruction results that are obtained using SW, we present an analysis of the obtained contrast based on coherent diffraction patterns from nanometre-sized colloidal particles deposited on a Si_3N_4 membrane.

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